Outline

- IC Background
- Lessons Learned
  - Training / Education
  - Data Management
  - QC: Impacts on Contractor
    - Project Management
    - Certifications
  - VT: Data Mining Findings
- Where are we going?

IC System

Global Positioning System (GPS)

Onboard Report System

Continuous Measurement System

Courtesy of Bomag

Roller Measurement Values

Ammann

k_b

Caterpillar

CMV, MDP

HAMM/Wirtgen

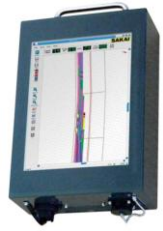
HMV

Bomag

E_{VIB}

Dynapac

CMV



Sakai

CCV

Courtesy Transtec, Inc.

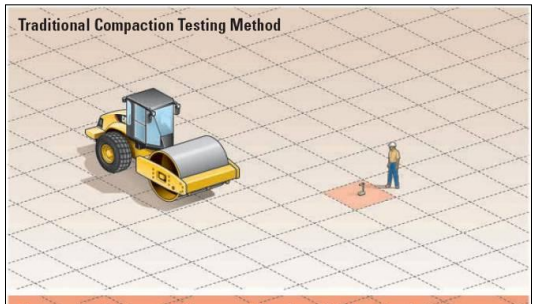
Benefits Observed by Contractors

- **Real-time feedback to operators**
  - Increased Accountability
  - Coverage
    - Prevent Gaps between passes
  - Compaction Curves
    - ↓ Number of Passes
  - Identify Weak Areas
  - Moisture Control (Grading Applications)
  - View Temp (HMA applications)
- **GPS System Transferrable**

Expected Benefits

- 100% Coverage
- Real-Time, Digital, Permanent Results
- Increased
  - Compaction Uniformity
  - Inspector Safety
  - Grade Control
  - Speed Control
  - Record Keeping
  - Planning/Staging
  - Pavement Life

Sampling Coverage



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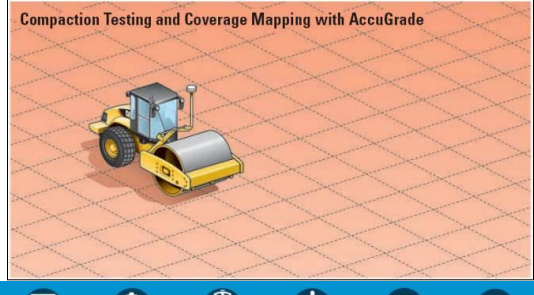


100 % Coverage

Courtesy of Trimble/Caterpillar

Expected Benefits (Cont.)

- Decreased
  - Spot Testing (QC / VT)
  - Maintenance Costs / Preservation Activities
  - Inspection Time
- Link
  - In-situ Properties → Design & Performance

Training / Education

LESSONS LEARNED

Required Project Specific Training

(Certification of Quality Control Personnel)

- **Department**
  - **Project Engineer**
  - **Inspector(s)**
- **Contractor**
  - **Field Grading/Paving Superintendent**
  - **QC Field Representative**
  - **IC Roller Operator(s)**

Required Project Specific Training

Table S-xx.2
Required Project Specific Training

Presented By	Topic
IC Representative (Note 1)	• General Background Information. • Details on system relevant to both the Contractor and the Department. At a minimum: ▪ Data transfer ○ Manual ○ Web-Based Storage (Cloud Technology) ▪ Data Backup ▪ Recommended Operating Settings ▪ Data storage capacity of on-board documentation system ▪ Base station and repeater use, or use of VRS / CORS GPS system
Grading and Base / Bituminous Engineer	• Special Provisions • Goals • Forms

Field Training with IC Manufacturer

- Completed outside of project specific training
- 'Hands on' operation of the IC system
  - On-Board Documentation System
  - Proprietary Software
  - Modem / Radio Setup use)
  - Recommended Operating Settings

Contractor Field Training (cont.)

- Base Station / Repeater
  - Use / Placement
  - Calibration Files
  - Compatibility
- Technical Support Available
  - Duration of Project

Data Management

LESSONS LEARNED

Data Volume – Massive Amounts!

SP1380-63 (TH35) – 2011

15 Miles

3 Compactors

11,207 Export Files

17,271,460 Rows (Raw Data)

7,750,844 Rows (Valid Data)

Data File Submittal

Daily Data Submittal

- All Passes Data *(entire data set / pass)*
- Proof Data *(final coverage)*
- *Format: ASCII / Text or directly importable into Veda*

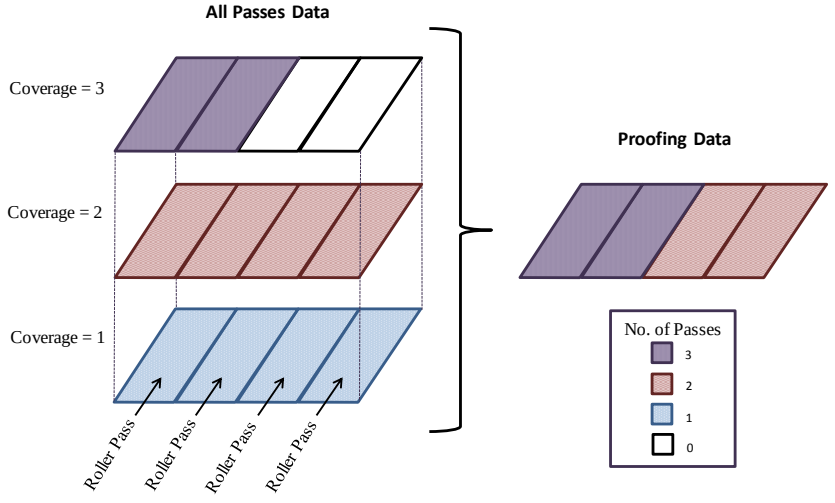
Raw Files

- Allow for future updated exports

Dbase Export

- Mapping Tool
  - Veda
  - ArcGIS
- Database
  - Oracle
  - Microsoft Access (Not Recommended)

Measurement Pass Data



Note: Each Roller Pass is performed as a Measurement Pass.

Data Review

- Proof Data (final coverage)
  - Final Pass Count
  - Final Stiffness
  - Final Temperature
- All Passes (entire data set / pass)
  - Compaction Curve
    - (Stiffness vs. Pass Count)
  - Temperature Curve
    - (Temperature vs. Pass Count)
  - Spatial Analyses
    - (Temperature, Pass Count, Stiffness)

Wireless Technology Needed!

(Now Available with Some Vendors)

- ↑ 'Near' Real-Time Review
- ↓ Handling Efforts
- ↓ Lost Data
  - Overwriting on Compactor
  - Human Error during Manual Transfer
  - Theft
- ↓ or Eliminate Duplicate Data

S-xx.2C Web-Based Storage

- Wi-Fi Capabilities
  - Modem or
  - Radio
- Transfer data directly to web-base storage (Cloud Technology)
- USB Port (Manual Transfer)

S-xx.2 Equipment Requirements

- Provide Department
  - Proprietary IC Software
  - Access to Web-Based Storage
- Duration
  - Prior to roller Certification
  - Until 6 months after final Grading Work (or final bituminous paving)

Intelligent Construction Data Management Tool

- Spatial Analysis
- Users:
  - Agency
    - Inspectors
    - Project Engineer
  - Contractor
    - Field Superintendent
    - QC Field Representative(s)
  - Specialty Units
    - Specification Refinement

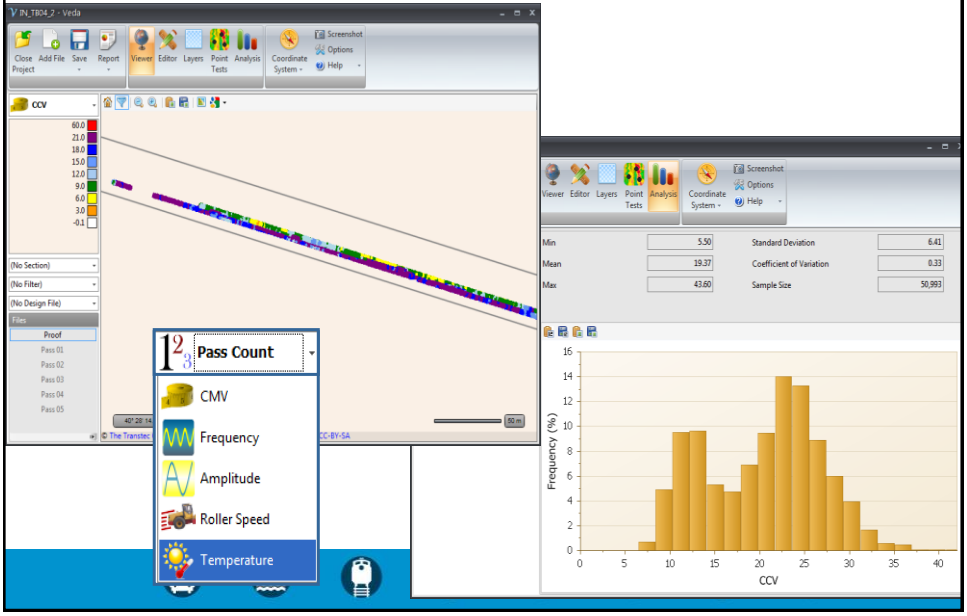
Veda

U.S.Department of Transportation
Federal Highway Administration

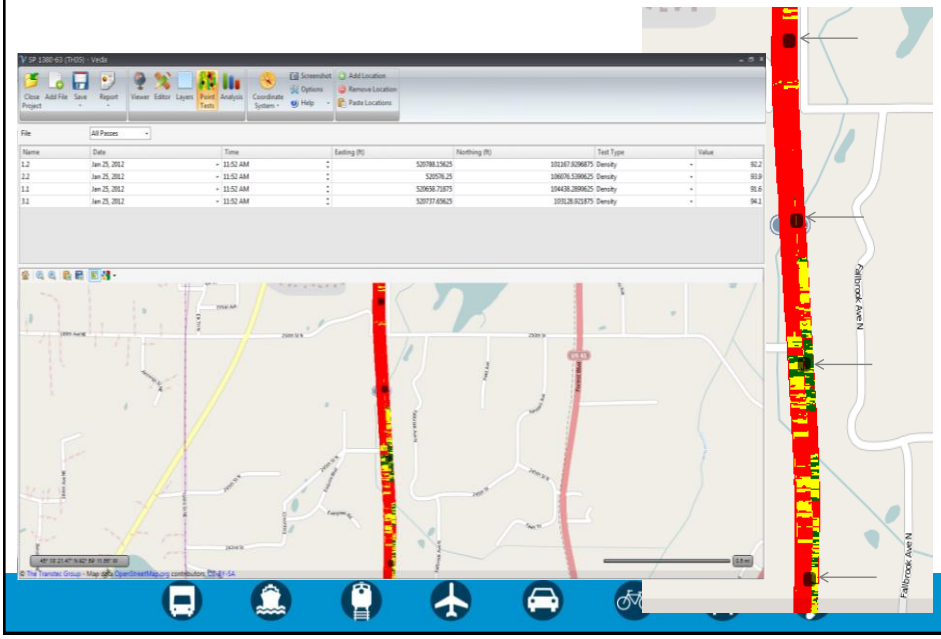
Minnesota Department of Transportation

THE TRANSTEC GROUP

View, Edit, Analyze



Editor and Point Tests



Quality Control (QC)

Impacts on Contractor – Project Management

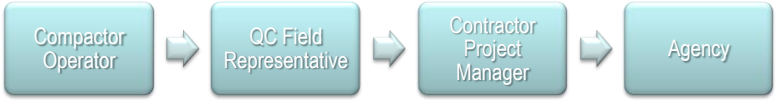
LESSONS LEARNED

Staffing

- ↑ Job Duties
- ↑ Skills
  - Computer Literacy
  - Organization Skills
  - Detailed
  - Communication / Leadership
- ↑ Resources
  - Temporary Hires
  - Switching Workers Around

Increased Coordination / Time

- Training
- Computer Equipment
- Roller Placement
- Data Transfer (for non-wireless transfer)



- Time already maxed!
- Daily Base Station / Repeaters Preparation

S-xx.2C Web-Based Storage

- Wi-Fi Capabilities
  - Modem, or
  - Radio
- Transfer Data directly to web-base storage (Cloud Technology)
- USB Port

S-xx.2C GPS Network

- System to Connect to:
  - Virtual Reference Station / Continuously Operating Reference Station (VRS / CORS)
- Poor Cellular Coverage
  - Real Time Kinematic – Global Positioning System (RTK-GPS)

Staging

- IC Equipment – Needed Multi-places at same time
- Haul Roads
  - Blocked by Measurement Pass Area
  - (Surface Prep. Important)
- Break Down of Compactor or IC System?

Satellite/Cellular Connectivity

Base Station Server Down?

Limited Cellular Data Coverage?

- Would further work be unauthorized?
- Affects on Incentives/Dis-incentives?
- QC / VT rates adjustments?

Quality Control (QC)

Impacts on Contractor and Agency - Certifications

LESSONS LEARNED

National Needs

- No Standardized Output
- No Independent Calibration Centers

(e.g., FWD National Calibration Centers, Profilographs)

Roller Certification

G&B-702 (06/04/12)

INTELLIGENT COMPACTION METHOD
ROLLER CERTIFICATION FORM

Grading & Base Manual 5-692.XXX PROJECT NO.:_____

CONTINUOUS COMPACTION CONTROL SYSTEM

Manufacturer Name	
Retrofit System (Yes/No):	
Automatic Feedback Control (Yes / No)	
Name of MV and Unit (e.g., CMV, unitless)	
MV Sensor Range (e.g., 0 to 150)	

ROLLER INFORMATION

Machine Model	
Machine Type	
Drum Width	
Drum Diameter	
Machine Weight	

ON-BOARD DISPLAY

Displays MV Output (Yes/No)	
Displays Alignment (Yes/No)	

VERIFICATION OF SYSTEM

Observed Avg MV over 'Soft' Material (Case 1)	
Observed Avg MV over 'Stiff' Material (Case 2)	
Measurements continuously recorded over Case 3 area (Yes/No)	
GPS appears to be recording correctly (Yes/No)	
MVs reflect sensor range (Yes/No)	
System appears to be reporting/recording correctly (Yes/No)	

OPERATING SETTINGS REQ'D DURING FINAL MEASUREMENT PASS

Roller Speed	
Vibration Frequency	
Amplitude	
Indicator for Double Jump	
Other:	

☐ All certification data transferred to web-based storage.
☐ All certification data manually transferred.

Contractor Signature:
I certify that the listed compactor complies with the CCC requirements:

VERIFICATION OF GPS ACCURACY

Position	Compactor		Indendepent Device (e.g., Rover)		Accuracy		
	X-Coordinate	Y-Coordinate	X-Coordinate	Y-Coordinate	Δ X	Δ Y	Pass / Fail
	(A)	(B)	(C)	(D)	abs [(A) - (C)]	abs [(B) - (D)]	
1							
2							
3							
4							
5							
6							
Is Offset Present between GPS antenna and center of drum (Yes/No)?							
If "Yes", has necessary offset been inputted and validated (Yes/No)?							

Agency / Owner Signature:
This Certification was Reviewed and Accepted by:

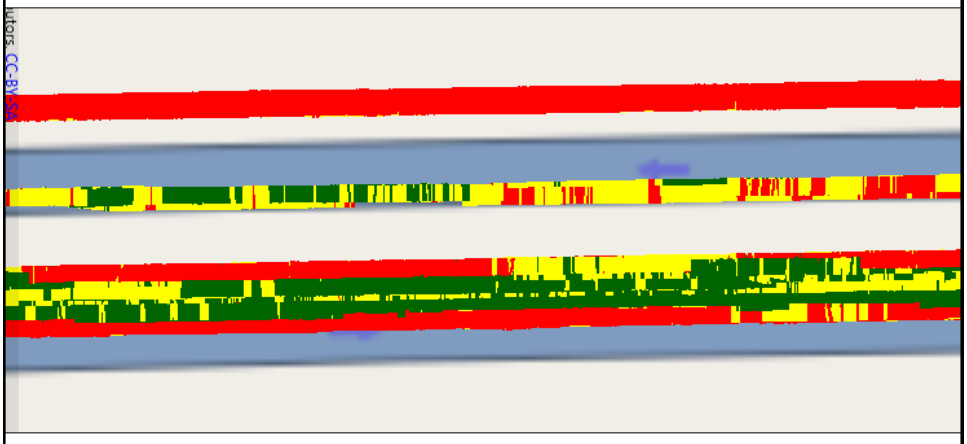
cc: Grading and Base Engineer

S-xx.3B Certification of IC Roller

TABLE S-xx.3
INSTRUMENTED ROLLER CERTIFICATION

Case No.	Demonstration	No. of Measurement Passes	Measurement Area	
			Width	Length
VERIFICATION OF ADEQUATE SENSOR RANGE				
1	Soft Material: MVs	1	≥ 14 ft (4 m)	≥ 300 ft (100 m)
2	Stiff Material: MVs			
VERIFICATION OF DATA CONTAINED WITHIN MEASUREMENT PASS FILES				
3	Requirements of S-xx.2	2	Layer	≥ 300 ft (100 m)

S-xx.3B4 GPS Accuracy



S-xx.3B4 Verification of IC GPS Accuracy

- Establish and mark a spot, on ground level
  - Prevent climbing onto compactor drum
- Collect and compare GPS coordinates
  - Instrumented Compactor
  - Independent Measuring Device
    - Calibrated using control point
- Acceptable ΔX & $\Delta Y \leq 0.5$ ft

Verification Testing (VT) – Data Mining Findings

LESSONS LEARNED

Verification Testing - Targets

One cannot easily implement a target stiffness value or coverage (pass count) as part of acceptance criteria.

COMPLEX

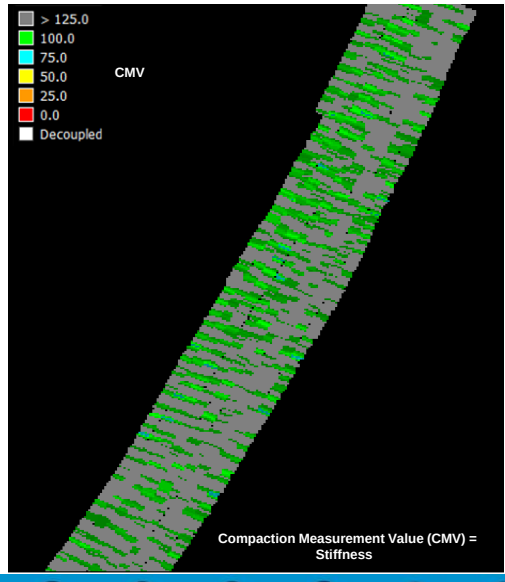
(IT HAS NEVER BEEN ACHIEVED IN MN)

Control Strip Areas

- Time Consuming / Costly
- Does it cut off the haul road?
- Large Number Constructed
  - Material Types (Proctors)
  - Moisture Content (~ ± 2 %)
- Difficulty Representing Fill
- Increased Inspection
- How to use Resulting CMV?

Photo Courtesy of Mathiowetz Construction

CMVs Affected by Surface Preparation



CMVs Affected by Surface Preparation (cont.)

- **Scraper**
  - Ruts
  - Wheel Tracks
- **Double Drum**
  - Additional Passes
  - Beyond Normal Use
- **Blade**
  - Eliminate Bumps
- **DW20 Packer**
  - Ensure Compaction
- **Vibratory Smooth Drum**
  - Ensure Smoothness
- **Proof Roll (Measurement Pass)**
  - Machine Drive Power
  - Pad Foot

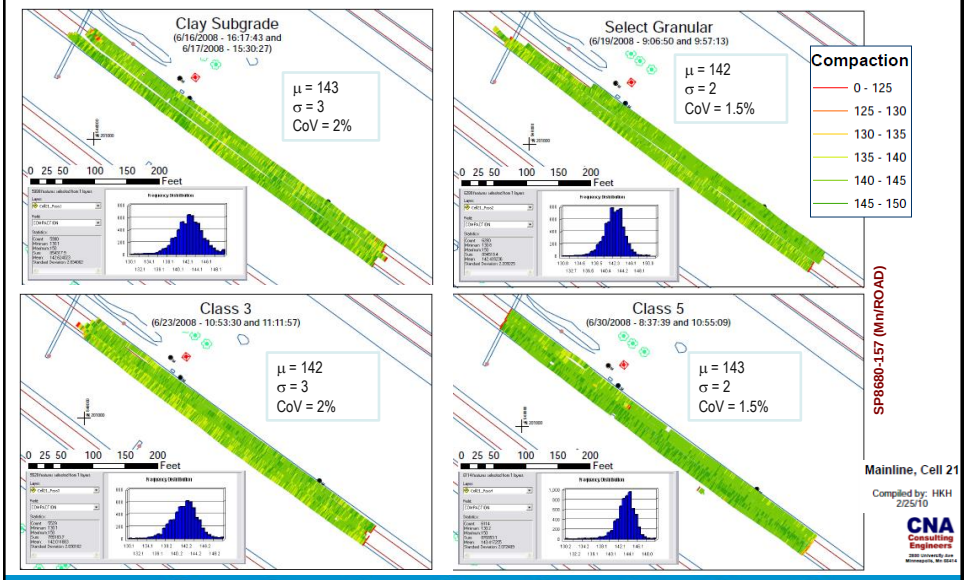
Photos Courtesy of Mathiowetz Construction

7 ft below Grading Grade
2-ft Intervals Required for Measurement Passes

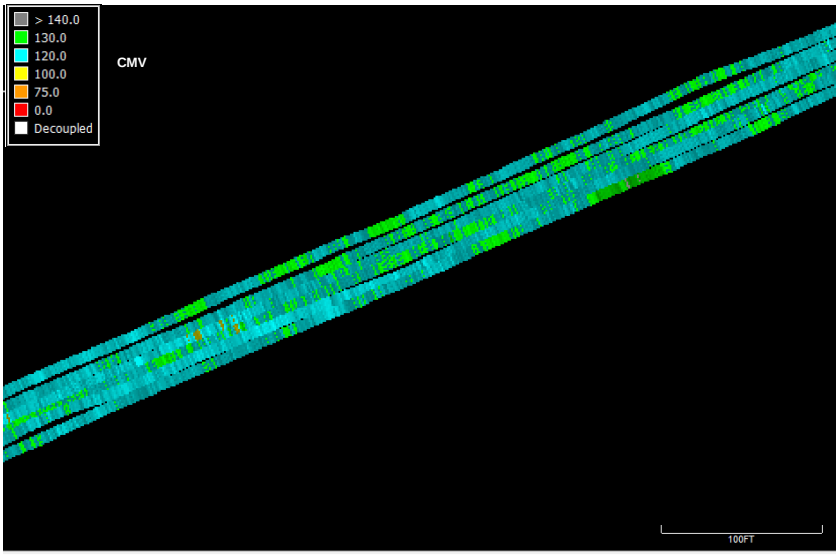
Other Factors Affecting CMVs

- Underlying Materials
  - Geogrid / Fabrics / Varying Soil Types / Rocks
- Bridging
- Moisture Content
- Compactor Operating Settings
  - Speed
  - Direction
  - Frequency
  - Amplitude
  - Slopes
    - Uphill vs. Downhill
    - Super-elevations

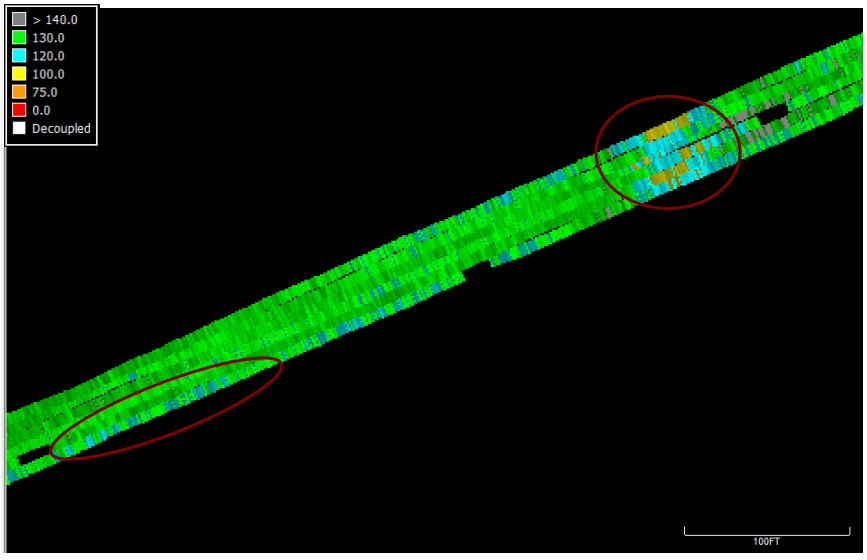
Uniformity CAN be captured



Ability to View Coverage

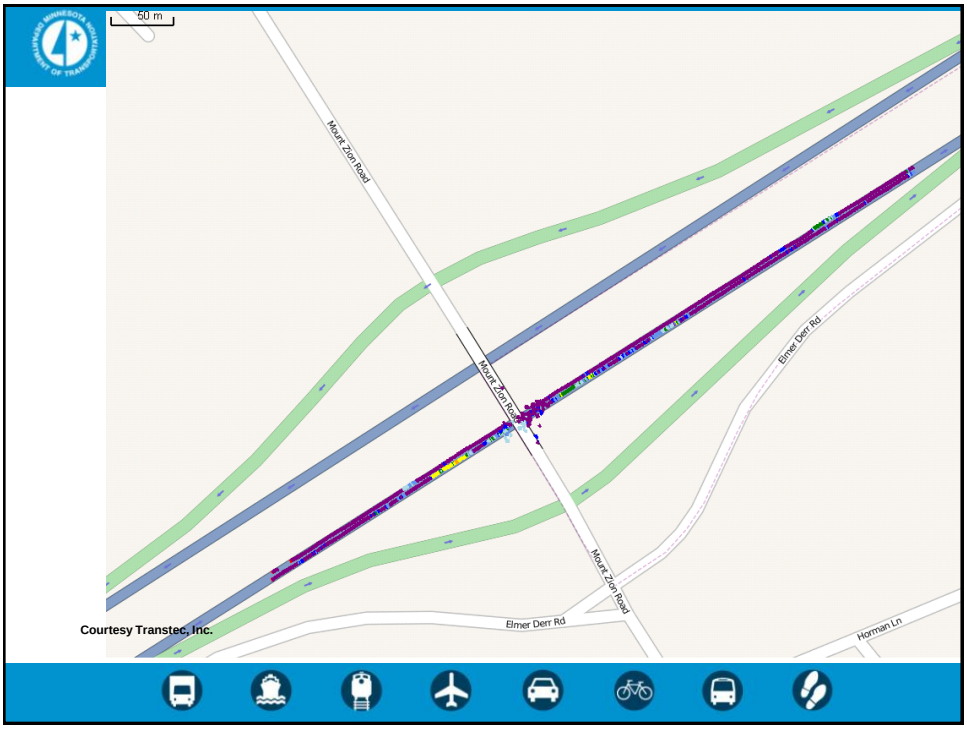


Ability to Find Weak Locations

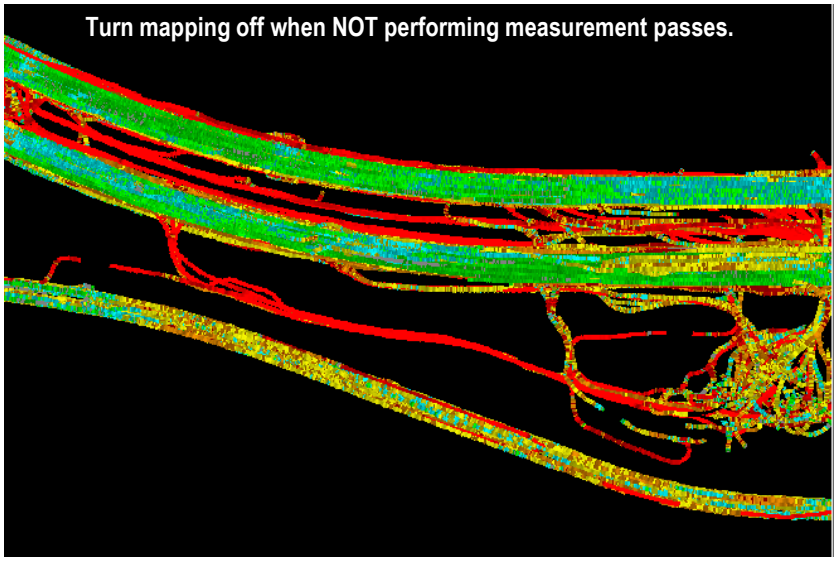


Affects of Urban and Tree Canopies

Photos Courtesy of Braun Intertec



Proofing File



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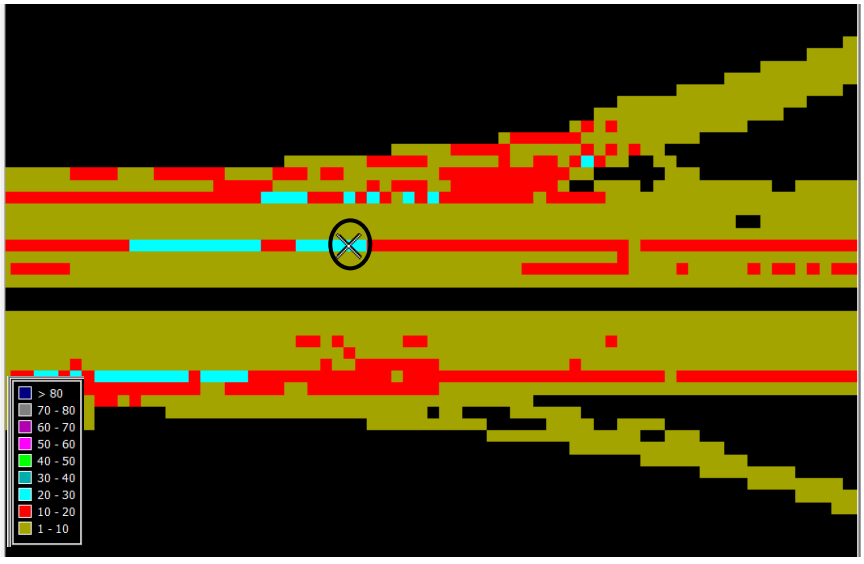
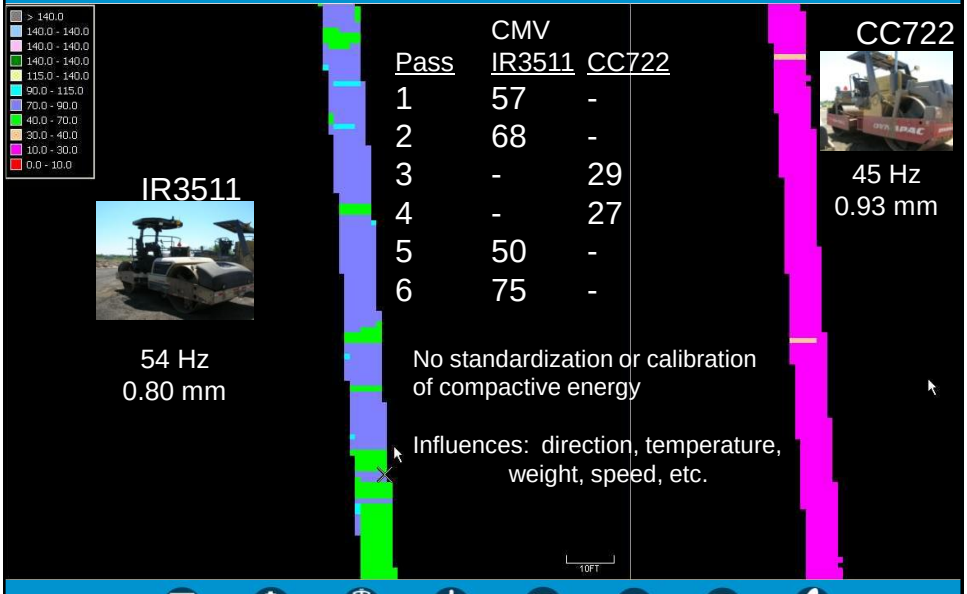


CMV Differences (same time/location)



S-xx.3C Measurement Passes

- Previously Required:
  - Passing:
    - 90% of the measurements ≥ 90%*IC-Target Value prior to placing next lift
  - Corrective Action:
    - Areas < 80%*IC-Target Value
- Currently not Requiring Control Strips

S-xx.3C Measurement Passes

- Previously Required:
  - Bottom of Fill / Cut up to grading grade.
  - Measurement Pass Layers:
    - ~ 2 ft.
- Currently Require Measurement Passes:

Table S-xx.4 Required Measurement Pass Locations	
Specification	**Measurement Pass Location**
2105 / 2106(SP)	Top of Subgrade *When the depth is within 6 ft (2 m) below of Grading Grade.*
	Grading Grade
2211	Top of the Base
2215	Top of the Reclaimed Base
2331	

Promote Certifications & IC Use

(A) Instrumented Roller Certification…….. …..5% Payment
(B) QC Field Rep. Certification…..……..…….. ..5% Payment
(C) IC Roller Operator(s) Certification……. 10% Payment

(D) 10% Measurement Pass Completion…… …8% Payment
(E) 40% Measurement Pass Completion …… 24% Payment
(F) 70% Measurement Pass Completion …… 24% Payment
(G) 100% Measurement Pass Completion ……..24% Payment

No payments for (D) – (G) until items (A) – (C) is approved.
No payment for (E) – (G), until item (D) is approved.
Payment for (D) – (G) will be made after Department review of data.
The Department will review the data within 10 business days after notification.

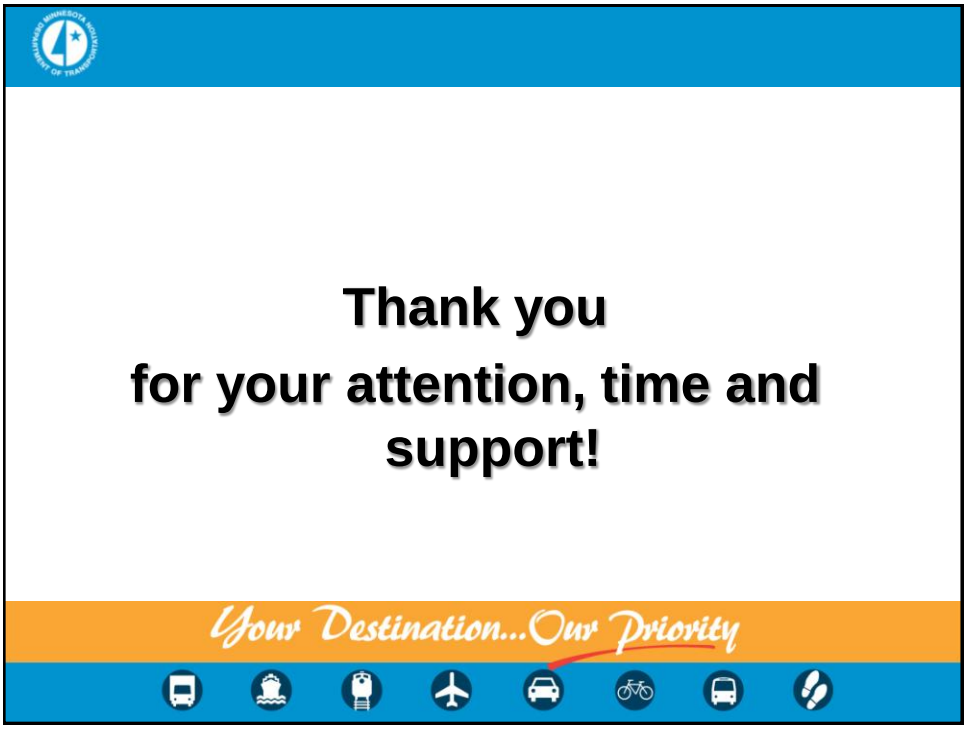
WHERE ARE WE GOING?

We can see the potential benefits.

Continue to pilot the technology.

2012 Construction Season

- Stabilized Full Depth Reclamation
  - 1 Pad Foot
  - 1 Pneumatic
  - 1 Double-Drum, Rubber-Steel
  - 1 Double-Drum Steel
- HMA Project (Entire Rolling Train)
  - 2 Pneumatic
  - 2 Double-Drum Steel


Thank you
for your attention, time and support!
Your Destination...Our Priority